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Special issue: invasive alien forest pest research

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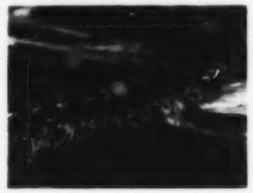
Science, trade, Canada's forests, and invasive alien pests: keeping forests safe and protecting trade

From the cover



Larvae of the Asian gypsy moth, an alien invasive forest pest repeatedly introduced to British Columbia aboard shipments of goods from its native Asia, feed on conifer needles as well as leaves of broad leafed trees. The adult female is an aggressive flyer, unlike the adult female European gypsy moth.

In a series of studies undertaken in the mid-1990s, Natural Resources Canada researchers determined that importers of goods from overseas were inadvertently bringing more than trade goods into British Columbia. The scientists trapped more than a dozen species of non-native bark and wood-boring beetles near warehouses close to the Port of Vancouver or detected them in wooden packaging materials collected from the port and warehouses. In another study, they discovered six species of non-native forest beetles established in nearby urban parks: one species originated in the subtropics, two species likely arrived from temperate Europe, two species are native to temperate northeast Asia, and one came from eastern North America.

The experiments were among the first in Canada to quantify a specific pathway by which non-native forest insects were entering the country, says Natural Resources Canada, Canadian Forest Service Forest Health Research Scientist Eric Allen (eallen@nrcan-rncan.gc.ca). "We were counting things to substantiate and quantify how problematic some of these packaging materials were. That sort of information was very much needed, because the international plant-protection standards that were just starting to be developed needed scientific support."

International trade is vital to Canada's economy. Forestry products accounted for almost $35 billion in exports and $3 billion in imports in 2006, and trade in nursery products was worth about $1.75 billion (2002). As trade around the world increases, length of time required to transport goods across oceans decreases, and more and more sealed containers are shipped from almost anywhere in the world directly to warehouses and depots almost anywhere in Canada, the risk of insects or diseases hitchhiking aboard trade goods into Canada increases. Raw logs, untreated wood products such as wooden crates or spools, and live plants are the biggest trade-related opportunities for exchange of invasive forest insects and diseases. An estimated 20 percent of non-native insects enter Canada aboard horticultural products; untreated wood is believed to be responsible for 73 percent of introductions of non-native insects and fungi.

Canada's reliance on exporting natural resource products makes it vulnerable to trade disputes: if trading partners believe a high-risk pest is established in Canada, they can refuse entry to Canadian goods unless the products have been certified free of the organism.

Since Allen and Canadian Forest Service Entomologist Lee Humble (lhumble@nrcan-rncan.gc.ca) conducted their beetle-trapping experiments, a number of international standards for protecting plant health have been developed and implemented by trading communities around the world These measures help to close gaps in Canada's borders that allow unwanted insects and diseases to enter the country.

On guard against pests

Three international agreements that Canada has signed address the spread of pests from one country to another: the 1992 Convention on Biodiversity, the 1998 Montreal Process Criteria and Indicators for the Conservation and Sustainable Management of Temporal and Boreal Forests, and the United Nations Food and Agriculture Organization's 1999 International Plant Protection Convention.

In Canada, the Canada Food Inspection Agency (CFIA) is responsible for keeping forests safe from non-native pests. The federal agency regulates movement of high-risk products into, from and across Canada, and works with other federal and provincial agencies, industry, as well as plant-protection agencies around the world to detect new introductions of non-native pests into Canada. It monitors and controls non-native pests that have become established, and determines the risks non-native pest species pose to the country's forests and economy. The agency also ensures Canada does not export materials that contain pests elsewhere: its pest-free certification programs are based on internationally recognized standards.

"Our primary focus is on preventing entry and spread," says Marcel Dawson, National Forestry Manager for the CFIA. "We use eradication measures when necessary, set up early-detection systems and conduct timely and reliable risk assessments. We must also address the effects of invasive alien pests on forest ecosystems—on composition, processes and resiliency—and on timber losses."

The CFIA is a science-based organization. The policies it proposes to government, the legislation it enforces and the regulations it administers must be scientifically sound to withstand scrutiny by diverse international agencies, such as the North American Plant Protection Organization, which provides a continental approach to plant protection, and the World Trade Organization, which supports trade and helps settle trade disputes.

Meeting the science requirement

The CFIA works closely with Natural Resources Canada's forest research labs. The Canadian Forest Service is Canada's main federal forest research organization. Canadian Forest Service researchers collaborate with the CFIA in the detection, identification and assessment of known and potential alien forest pests. They also assist in the development of detection methods and tools to determine likelihood of alien-species establishment in Canada. These services, provided under a memorandum of understanding between the two organizations, are critical to the development and implementation of effective regulatory and pest management strategies.

CFIA forest health officers now work at the Pacific Forestry Centre, increasing collaboration and communication opportunities.

"We have pest issues being dealt with by scientists from both organizations," says one of those officers, CFIA Forest Health Specialist Shane Sela. "We also have trade issues—whether they are evaluating our trade in forest products from China or lumber to Australia, a lot of the plant-health and phytosanitary trade questions are science related. Because I can walk over and talk to researchers studying these issues, we can find answers to problems more quickly and build the most appropriate, science-based regulatory frameworks to deal with issues."

Forests located near warehouses, train depots and shipping ports are especially vulnerable to introductions of non-native forest pests.

Tools to help

Invasive Alien Species Strategy for Canada

In 2004, Canada's federal, provincial and territorial governments ratified an Invasive Alien Species Strategy. This strategy, which involves many government agencies, deals with threats by all invasive alien species—aquatic as well as terrestrial; agricultural as well as forest; plant as well as animal. It emphasizes prevention, early detection and rapid response to pest introductions, and also addresses containment, control and eradication.

National Forest Pest Strategy

Federal, provincial and territorial governments are currently developing a National Forest Pest Strategy to foster a collaborative approach for dealing with both native and alien forest pests. The strategy will address the best ways to work together to prevent, detect, assess and respond to insect pests.

The new strategy builds on the Invasive Alien Species Strategy. Pacific Forestry Centre Director General Sue Farlinger, one of the leaders in developing the National Forest Pest Strategy, says, "It ensures everyone uses the same language, the same information, and the same models for assessing risk of each forest pest of national concern. Responses to those risks will therefore be based on the best science and most accurate information available, and thus be much more effective."

Sources

An Invasive Alien Species Strategy for Canada (2004) can be viewed at www.cbin.ec.gc.ca/issues/ias_documents.cfm?lang=e.

These other related articles are available from the Canadian Forest Service online bookstore: "Forest biosecurity: alien invasive species and vectored organisms" (2006); "Surveillance for invasive wood borers: national and international perspectives" (2003); "Nonindigenous species introductions: a threat to Canada's forests and forest economy" (2002); "Implications of non-indigenous insect introductions in forest ecosystems" (2001); "Exotic wood-boring beetles in British Columbia: interceptions and establishments" (1998).

"Science and regulation: a Canadian approach to invasive alien species" (2005) is available at www.fao.org/docrep/008/y5968e/y5968e0n.htm, and "Alien Invaders: Non-indigenous Species in Urban Forests" (2004) is available at http://www.treecanada.ca/cufc6/proceedings/papers/Humble.pdf.

Alien pest profile

Pine shoot beetle

Tomicus piniperda

At risk: pines (main host), fir, larch, spruce and Douglas-fir • **Native to:** Eurasia • **Distribution:** Asia, northern Africa and Europe, eastern U.S., Ontario and Quebec • **First Canadian record:** confirmed in seven counties in southwestern Ontario, 1993; likely arrived in Canada in wood packaging materials shipped from overseas. • **Signs:** fine, reddish-brown sawdust-like substance on the bark surface of trees; whitish tubes of tree sap around entrance holes on the bark surface.

photo: Klaus Bolte, Canadian Forest Service

About the images • During Klaus Bolte's 39-year career as a technician with Natural Resources Canada, Canadian Forest Service, he pioneered the photographic technique used to capture some of the insect images shown on these pages. He used a digital camera mounted on a microscope to photograph individual insect parts, then re-assembled them electronically into a detailed, in-focus image of the entire insect.

Scientists search for irresistable pest perfumes

Many insects rely on scent to communicate with each other and to find food and hosts. Setting out traps baited with insect and host-tree smells has long been a technique used by plant health officials to detect and track unwanted pests.

But the scents currently used by the Canadian Food Inspection Agency (CFIA), the federal organization responsible for keeping Canada's forests safe from alien forest pests, fail to entice all insects of potential concern into detection traps. For instance, baited traps have yet to consistently capture emerald ash borer or Asian longhorned beetle, two non-native insect species infesting regions of southern Ontario.Scientists at Natural Resources Canada are helping the CFIA close these gaps by testing new lures and scent combinations.

"Right now, we're quantifying what species the lures are picking up and what species they're missing," says Canadian Forest Service Entomologist Lee Humble (lhumble@nrcan-rncan.gc.ca), from the Pacific Forestry Centre. "Our goal is to develop more generic lures and extend the repertoire of lures used to trap non-native insects that may have already become established in Canada."

The researchers are testing combinations of scents released by common host trees, in addition to insect pheromones—scents released by insects that prompt behaviours in other members of the same species.

"Pheromones target specific species or groups of species, and are usually much more sensitive than host-tree compounds," says Atlantic Forestry Centre Research Scientist Jon Sweeney (jsweeney@nrcan-rncan.gc.ca). "A target insect encounters it, and it responds like, 'hey, there's one of me out there calling, and it's saying let's get together.'"

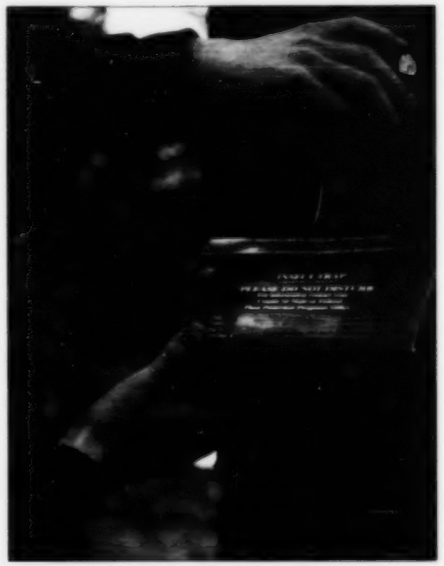
But pheromones limit the range of insects detected. "By including a pheromone in your trapping system, you increase sensitivity or detection ability for a particular pest, but you also narrow the focus of that lure," Sweeney says. "It simply won't work on a broader range of species."

"There are hundreds or thousands of insects we don't want entering this country," says Research Scientist Peter deGroot from the Great Lakes Forestry Centre (pdegroot@nrcan-rncan.gc.ca). "You can put species-specific pheromones out, but it becomes very cumbersome to place and maintain hundreds of traps, each with a different pheromone for a different insect. And in many cases, we don't have the pheromones, and we have to rely on other things to attract the insect into an area and into a trap."

Lures based on tree scents, which include ethanol and components of turpentine, entice broader ranges of insect species by mimicking stressed or injured trees—the preferred targets of most wood- and bark-boring insects.

"Determining a suite of lures that attracts a broad range of species is a way to lower the risk of infestation by a non-native pest," says deGroot. "It helps us find and counter insect problems before they blow up so big we can't eradicate them."

Humble, Sweeney and deGroot began testing in 2006. They placed lures at sites in Nova Scotia, Vancouver and southern Ontario that are considered high risk for introductions of alien forest insects. Sites include ports, freight depots, and warehouses. The scientists are documenting and analyzing results collected during the last two years, and will be setting out test traps again in 2008.



Plant-protection officials set out insect traps baited with scents that attract beetle and moth species to detect and monitor the presence of forest pests. Canadian Forest Service researchers are trying to determine the most effective scents and scent combinations to lure non-native wood-boring and bark beetles into traps.

photo: USDA APHIS PPQ Archive, USDA APHIS PPQ, Bugwood.org

Sources

Look for these related reports on the Canadian Forest Service's online bookstore: "Detection of wood-boring species in semiochemical traps" (2007); "Effect of semiochemical release rate, killing agent, and trap design on detection of *Tetropium fuscum* (F.) and other longhorn beetles (Coleoptera: Cerambycidae)" (2006); "Host volatile attractants and traps for detection of *Tetropium fuscum* (F.), *Tetropium castaneum* L., and other longhorned beetles (Coleoptera: Cerambycidae)" (2004); "Response of *Monochamus* (Col., Cerambycidae) and some Buprestidae to flight intercept traps" (2003).

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Historical invasive pest records become accessible

With each new potentially invasive forest pest introduced into Canada, forest health officials must assess its potential risks before effective control or eradication can begin. Often, however, few data are available to do this.

This need for information spurred Natural Resources Canada Research Entomologist Vince Nealis and his colleagues across the country to amass the Canadian Forest Service's historical records of invasive forest pests into one centralized, easily accessible data system with applications for mapping and analyzing these data.

"If you want a risk analysis on pests you know only a little about, your best sources of information are pests you know a lot about," Nealis says (vnealis@nrcan-rncan.gc.ca). "Hundreds of forest insects have invaded Canada during the past 100 years, and their establishment, control, progress, spread, host plants, and so on, have been documented by the Canadian Forest Service."

Natural Resources Canada is launching the Forest Invasive Alien Species database (FIAS-DB) this year. It contains all records of invasive forest insects and diseases found by the Forest Insect and Disease Survey (FIDS), annual surveys collected by the Canadian Forest Service until 1995. Records are derived from an existing database of survey records dating back to 1950 and from annual reports published as far back as the early 1900s. Specimen records from the forest service's insect, fungus and plant collections are also used. When researchers, entomologists, forest health specialists and forest managers log onto the system, they can track historical spread of invasive alien insects and diseases through Canada's forests.

They can also extrapolate that information into estimates of how new invasive insects or diseases will behave.

"There are dozens of species, like gypsy moth, satin moth, and balsam woolly adelgid, for which we have decades of records," says Nealis. "We know where and when they came into Canada, we can calculate how fast they spread, whether or not they went along certain pathways—exactly the kinds of things people want to know about invasive species: where are they going? How are they going to get there? What kind of damage are they going to do? What should we do? We can now plug into these historical data for scientific and economic decision-making. We're going to be able to answer these kinds of questions with the best information available."

A mapping interface allows users to map invasive species finds and combine them with other information, such as transportation corridors, tree species at risk, or climatic zones. "And," says Canadian Forest Service Systems Analyst Kevin Porter (kporter@nrcan-rncan.gc.ca), leader of the Knowledge Synthesis Group at the Atlantic Forestry Centre in Fredericton, "users can access copies of original reports. It directs you right to the record in the original FIDS database or, if the record was found in a report, we've scanned those reports and formatted them as searchable PDF files. So you can go right to the reference."

The FIAS-DB will run on the Canadian Forest Service data-sharing infrastructure, CFSNet, designed primarily for researchers and forest managers. An associated public web portal, launched this fall by the Laurentian Forestry Centre, provides easy, centralized access to the database, as well as pest fact sheets, policy, laws and regulations and other information regarding forest invasive alien species in Canada.

"Scientists are working hard on insects and diseases; they've been acquiring information and publishing papers," says Forest Health Project Leader Pierre DesRochers (pidesroc@nrcan-rncan.gc.ca)), who oversees the web portal. "This website is a way to make all that available to the largest audience possible."

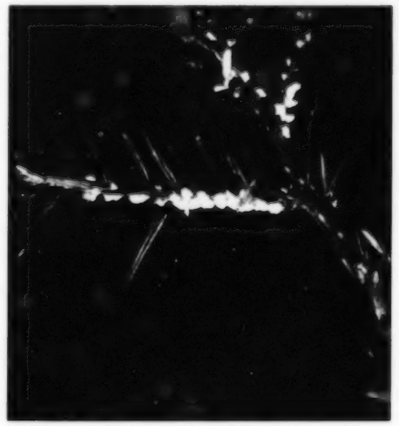
Alien pest profile

Balsam woolly adelgid

Adelges piceae

At risk: all true firs, with amabilis and grand firs attacked most frequently in British Columbia • **Native to:** Europe **Distribution:** Europe, eastern and western North America • **First Canadian report:** Nova Scotia, 1910; British Columbia, 1950s. Quarantine areas set up in British Columbia to prevent spread of this insect. • **Signs:** woolly masses on the lower bole, and possibly on large branches, in the spring and summer, leading to galls; crown gout and top kill

photo: Robert L. Anderson, USDA Forest Service, Bugwood.org



International research collective provides science to safeguard forests and trade around the world

Natural Resources Canada Forest Health Research Scientist Eric Allen (eallen@nrcan-rncan.gc.ca) leads the Forest Invasive Alien group at the Pacific Forestry Centre. As part of his work, he chairs the International Forestry Quarantine Research Group, is deputy coordinator of the International Union of Forest Research Organizations working group, Alien Invasive Species in International Trade, and serves on the North American Plant Protection Organization forestry panel and the United Nations' International Plant Protection Convention (IPPC) Technical Panel for Forestry Quarantine. He answers questions about the International Forest Quarantine Research Group.

What is the International Forestry Quarantine Research Group?

It is a vehicle by which critical forest-related quarantine issues can be addressed through discussion and collaborative research. Really, IFQRG serves as an access point to scientists, plant-health experts and industry working on these issues throughout the world.

Serving the Commission on Phytosanitary Measures and linked to plant protection agencies through the UN Food and Agriculture Organization, we are affiliated with the International Union of Forest Research Organizations working group, Alien Invasive Species in International Trade, which brings together the broader forest science community to deal with forest quarantine issues.

What does IFQRG do?

We analyze available science on which international forest protection agreements like International Standard Phytosanitary Measure (ISPM) #15 are based. We also identify and work to fill research gaps through collaborative research, and provide scientific advice on plant protection strategies to organizations such as the IPPC Technical Panel on Forest Quarantine.

Who are members?

At the people level, IFQRG attracts forest scientists and plant protection officials from around the world who meet, communicate, and collaborate on research on forest-quarantine issues. Participation is open to all. Currently, more than 50 scientists and plant-protection officials from more than 25 countries participate.

Why is IFQRG important?

The development of international trade standards for plant protection is critical for reducing the movement of pests around the world. Also, under the World Trade Organization–Sanitary and Phytosanitary (WTO-SPS) agreement, plant protection regulations must be based on sound scientific data. If they aren't, the measures may be challenged, trade disrupted, and forests put at risk. IFQRG finds or provides the science on which these regulations are based.

Why is the Canadian Forest Service involved in IFQRG?

The spread of exotic forest pests threatens Canada's forests and its international trade of forest products. Preventing pest introductions is better for our forests, and less expensive ecologically, economically and socially than controlling pest infestations once they get here. The Canadian Forest Service supports scientifically based preventative international standards, like ISPM #15, which requires all wood packaging used in trade be treated either with heat or methyl bromide. These standards protect our forests from such things as Asian longhorned beetle and sudden oak death. And because these standards protect our trade—applying these regulations helps us to not move our pests elsewhere, which could also lead to trade problems.

What is IFQRG working on now?

We've just completed a scientific evaluation of risks associated with bark on wood packaging in support of the review of ISPM #15 and provided this to the IPPC Technical Panel on Forest Quarantine. We're also coordinating scientific research for more wood packaging treatments, including microwave and fumigation alternatives to methyl bromide.

We're helping ensure that development of treatments to rid trade goods of invasive pests is done in a scientifically sound way. We're also developing criteria for assessing efficacy of treatments, and we're looking at high-risk pathways—notably, plants for planting and trade in raw logs.

This work is being done by member countries and by Canada.

Sources

"Application of a real-time PCR method for the detection of pine wood nematode, *Bursaphelenchus xylophilus*, in wood samples from lodgepole pine" (2007) and "An effective PCR-based diagnostic method for the detection of *Bursaphelenchus xylophilus* (Nematoda: aphelenchoididae) in wood samples from lodgepole pine" (2005) are available from the Canadian Forest Service online bookstore.

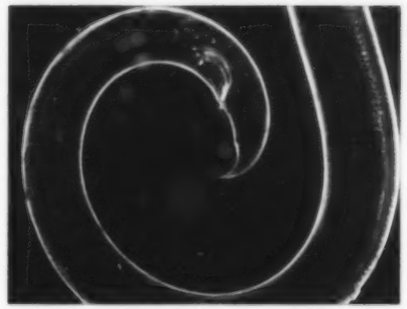
New diagnostics protect Canada's softwood trade

Molecular diagnostic methods developed by researchers at Natural Resources Canada and the Canadian Food Inspection Agency are helping Canada maintain access to international forest export markets. The methods detect presence of pine wood nematode in wood by identifying species-specific protein gene sequences.

Pine wood nematode is a microscopic roundworm native to North America. Although it rarely, if ever, affects North American tree species, it causes pine wilt disease in non-native conifer species and has extensively damaged coniferous forests in Asia. Finds of the nematode in wood imported from North America in the 1990s sparked a series of import restrictions on softwood lumber, chips and logs, prefabricated housing and wood packaging from North America. These goods now must be treated prior to export to Europe, Korea and China, and treatment documentation must accompany the goods.

However, not all North American coniferous forests are infested with the nematode, and not all softwood trees harvested in Canada carry it. Canadian Forest Service Research Biologist Isabel Leal and her team's new DNA-based techniques provide a powerful tool for testing for the nematode's presence, and for testing the efficacy of internationally required phytosanitary treatments against the nematode.

"This is a refined molecular diagnostic method to quantify and detect pine wood nematode extracted from field samples," says Leal (ileal@nrcan-rncan.gc.ca), who led the study. "It eliminates the intermediary steps required by earlier molecular diagnostic methods, which required the organism to be extracted and cultured in a lab. Because of this, it is much faster."



Countries in Europe and Asia require Canadian softwood lumber products to be treated prior to export, because of pine wood nematode. Photo: L.D. Dwinell, USDA Forest Service, Bugwood.org

It also has the potential to screen a larger number of samples compared to traditional, morphological diagnostics.

The new method can be used with both conventional and real-time polymerase chain reaction (PCR). Real-time PCR can also quantify the number of individual nematodes in a sample.

Building on their research, Leal and her team are now investigating methods for determining whether nematodes detected in diagnostic samples are dead or alive.

Alien pest profile

Asian longhorned beetle

Anoplophora glabripennis

At risk: many hardwoods, including maple, birch and poplar • **Native to:** Asia • **Distribution:** Asia, Chicago, areas of New York state and New Jersey, Germany, France, Austria • **First Canadian record:** Toronto, 2003; likely via untreated wood packaging materials; monitoring and eradication are in effect • **Signs:** round holes and oval wounds on bark, sometimes leaking sap; coarse sawdust on branches or at tree base

photo: Klaus Bolte, Canadian Forest Service

Alien pest profile

Sudden oak death

Phytophthora ramorum

At risk: oaks, maples, Douglas-fir, roses, raspberry, and many other plants • **Native to**: possibly eastern Asia • **Distribution:** Germany, the Netherlands, California and Oregon • **First Canadian record:** Vancouver, on nursery stock, 2003; eradication and monitoring continue. • **Signs:** vary with host plant and may include brown or black spots on leaves, and bleeding cankers on trunks or stems

photo: Joseph O'Brien, USDA Forest Service, Bugwood.org

Genetic passports: First standardized DNA library will enable rapid identification of non-native species

A rapid DNA-based diagnostic system for invasive forest pests

- would reduce economic losses, particularly of perishable goods, while identifications are sought;
- would reduce misidentifications during early phases of pest-species establishment;
- would enable prompt access to literature concerning control strategies or the risks that pests pose.

If only insects and microorganisms traveled from country to country with identification papers ... Forest health specialists would then be able to respond quickly and effectively when an invasive pest threatened Canada's forests.

Although bugs and fungi don't carry passports, every organism does carry unique information about its identity in its DNA.

Scientists at Natural Resources Canada are working with researchers from other federal agencies, universities, museums and other organizations in Canada and around the world to establish a system for verifying identity and tracking movement of species. By contributing genetic profiles of species of wood-boring beetles, moths, fungi and other forest pests, Canadian Forest Service Entomologist Lee Humble and Research Scientist Richard Hamelin are helping the Canadian Barcode of Life Network build a DNA diagnostics database of all species found in Canada.

"You know when you are at the check-out counter at the grocery store, and the clerk scans the UPC labels, and all the information appears on the screen? This works on a similar principle," says Humble (lhumble@nrcan-rncan.gc.ca).

In this case, a 650-base-pair sequence isolated from an organism's DNA acts as the species-specific barcode. The web-based, diagnostic Barcode of Life Systems database archives the sequences.

When the database is complete, users will be able to search for and accurately identify organisms without requiring taxonomic expertise or extensive, time-consuming laboratory analyses. This will speed up inspection of products at borders, help distinguish undesirable plant or animal material in trade goods and packaging, verify food products, or identify disease-causing organisms.

As one of the project's principal investigators of forest pests and biological forest invaders, Humble is focusing on Barcode of Life Systems potential applications for identifying and tracking invasive forest pests.

"A DNA-based system that enables recognition of newly arrived species of quarantine significance will be invaluable to pest regulators and forest health people," he says. He is working to establish the barcode diagnostics system and integrate it into Canada's invasive species detection and surveillance program.

"The barcode system supports the national forest monitoring system," he says. "It applies directly to detection and identification of native and non-native pests. The Barcode library is the foundation for all of it."

Humble, based at the Pacific Forestry Centre, and colleagues from the universities of Guelph and British Columbia and from Agriculture and Agri-Foods Canada are contributing DNA barcodes of wood-boring beetles, aphids, scales, adelgids and moths that feed on Canada's forests. At the Laurentian Forestry Centre, Canadian Forest Service Research Scientist Richard Hamelin's team is concentrating on sequencing genomes of fungi found in the country's forests.

Already, his team has identified an alien rust species attacking two different host species in Canada. "DNA barcoding allowed us to connect the very different stages of its life cycle on very different hosts," says Hamelin (rhamelin@nrcan-rncan.gc.ca). "Basically, this shows this rust can reproduce and establish itself and overwinter here. This is the kind of result we're expecting more of in coming years, as the database gets populated with sequence information."

The rust, *Melampsora larici-populina*, is considered by the Canadian Food Inspection Agency to be a low-risk introduction in eastern Canada, unlike some other species that have entered Canada in the past. Chestnut blight killed off most American chestnuts throughout eastern North America's hardwood forests in the late-19th century, and white pine blister rust destroyed British Columbia's abundant western white pine forests after it was introduced on imported nursery plants in about 1910.

Even as the barcoding system is being developed, it is helping researchers discover new species, identify closely related species, such as European gypsy moth and Asian gypsy moth, map distribution of a species, and trace original populations as they disperse across countries and between continents. For instance, based on genetic records in the database, all European gypsy moth populations introduced into British Columbia during the last few years have been found, through DNA barcode comparisons, to have originated from existing populations in southern Ontario.

Traditional methods for identifying species are based on the species' physical characteristics, and can take months of searching scientific reports and involve dozens of people. According to University of Guelph zoology professor and founder of the DNA Barcoding network Paul Hebert, Barcode of Life systems can deliver results on some species as quickly as within a few hours. The goal is to get that down to minutes, and make it portable.

"What we'd like to see is a hand-held device that samples and sequences an organism's DNA, and then matches it to data in the Barcode of Life System," he says. "You could beat all the bugs out of a tree onto a drop sheet and make a milkshake out of their legs or some other part of them, and the device would be able to identify every species in that DNA milkshake. All within a matter of minutes."

And, he says, "if there's no match in the database, that would mean you need to look more closely at the tree."

Such a device would allow field technicians, plant-protection agents, customs inspectors and investigators to identify pathogens and pests on the spot.

In the meantime, researchers are busy populating the database with species information. Each species barcode results from barcodes of multiple specimens being sequenced and compared. Unclear or new species must be verified. Species barcodes must be accompanied by specimen images and collection records. As well, specimens must be stored in publicly accessible museums, so that, if there are questions in the future, researchers can go back and re-examine the specimens.

Hebert says the goal of the Canadian Centre for DNA Barcoding, which opened at the University of Guelph in May, is to barcode 100,000 species in the next five years. Although emphasis focuses on filling the database with information on Canadian species, DNA barcoding will soon be going international. Foundations for the International Barcode of Life Project have been laid, with researchers from 25 countries expressing interest.

When Humble first got involved in the Barcode of Life Network in 2005, research requiring DNA barcoding was considered by many to be difficult and expensive. "People were wary and uncertain of it two years ago," says Humble, "but now there is recognition that this technology and the barcode system in general will be key to any progress made in regards to prevention and control of spread by invasive alien species."

Alien pest profile

European spruce bark beetle

Ips typographus,
and its fungus associate, *Ophiostoma polonicum*

At risk: spruce and other conifers. The fungus associated with the beetle kills trees. Scientists fear native spruce bark beetle species may start carrying the fungus, as happened with Dutch elm disease • **Native to:** Eurasia • **Distribution:** Europe, Asia • **First Canadian record:** Montreal, 1996; intercepted in detection traps; likely arrived in untreated wood packaging materials.
Signs: red-brown dust in bark crevices, round holes, small tubes of resin extruding from the bark, red-topped trees

photo: Klaus Bolte, Canadian Forest Service

Alien pest profile

White pine blister rust

Cronartium ribicola

At risk: five-needle pines, including western white pine, limber pine, eastern white pine. • **Native to** Asia • **Distribution:** Asia, Europe, North America • **First confirmed Canadian record:** Vancouver, 1910, via nursery stock from France, but had been introduced to eastern North America in 1898 on nursery stock from Germany. The rust decimated British Columbia's western white pine and has eliminated western white pine. Canadian Forest Service researchers are investigating genetic resistance in western white pine to the rust. • **Signs:** First symptoms include small, yellow or red spots on needles. Within a year or two, cankers are found on branches and stems. These may be swollen and have a yellowish margin.

Sources

More information about DNA barcoding and the Barcode of Life Network can be viewed at www.barcodinglife.org and www.bolnet.ca

Information on *Melampsora larici-populina* is available at www.apsnet.org/pd/searchnotes/2005/PD-89-1242B.asp.

Software tool projects effects of changing climate on range of forest pests

Canada's climate is changing, and forest pests are on the move.

In order to track and predict long-term effects of a warming climate on pests, Natural Resources Canada scientists use a software tool originally developed to help forest managers plan short-term pest control or sampling activities. This tool, called BioSIM, links insect life-cycle models to weather data and manages their output to determine the timing of specific stages in an insect's life cycle—for instance, when an insect reaches the stage most vulnerable to pesticide applications. BioSIM has recently been extended to help in forecasting where current or future climates might favour invasion by an alien species because the weather is, or will be, more suitable for its survival.

"The success of forest pest control programs hinges on the vulnerability of pest populations at the moment of intervention," says Canadian Forest Service Research Scientist Jacques Régnière, who studies insect population dynamics out of the Laurentian Forestry Centre in Quebec City and developed BioSIM. "With insects, weather conditions are a controlling factor."

In order to predict long-term climate effects on insect populations, the researchers use data from climate scenarios generated by the Canadian Global Circulation Model that extend many decades into the future.

"Taking BioSIM from immediate applications to seasonality modeling and establishing probability over long time periods was a bit of a leap in complexity, but not much of a change in paradigm," says Régnière (jregnier@nrcan-rncan.gc.ca). "Whether you're looking for short-term or long-term views, it uses the same technology: weather-data management and model-output synthesis."

Régnière teamed up with Pacific Forestry Centre Insect Ecologist Vince Nealis (vnealis@nrcan-rncan.gc.ca) and Atlantic Forestry Centre Systems Analyst Kevin Porter (kporter@nrcan-rncan.gc.ca) to determine probable range expansion of gypsy moth in Canada. At the Canadian Food Inspection Agency (CFIA)'s request, they analyzed historical records from Natural Resources Canada's new Forest Invasive Alien Species Database (see page 5), and current and likely future range of gypsy moth in Canada, based on the Gypsy Moth Life Stage model, climate suitability and host distribution. Using the results, the researchers devised recommendations for gypsy moth management strategies, which they then submitted to the CFIA.

"The real benefits of models like BioSIM from a quarantine management point of view," says CFIA Forestry Specialist Shane Sela, "are that they allow us to better assess risks, and more effectively allocate resources to critical areas where potential risk is highest."

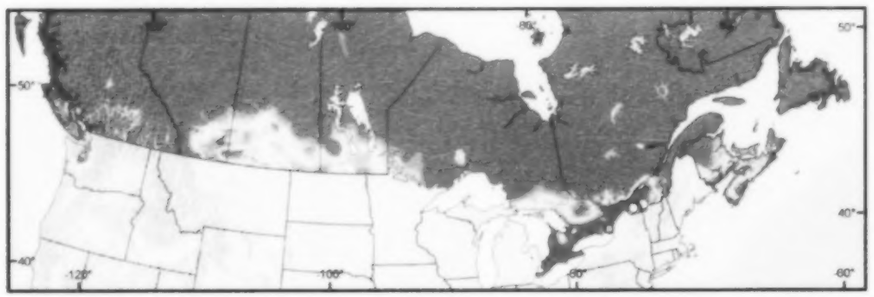
More recently, Régnière worked with Pacific Forestry Centre Insect Ecologist Allan Carroll (acarroll@nrcan-rncan.gc.ca) to predict range expansion of mountain pine beetle in western Canada. According to their results, eastward invasion by the beetle will continue if current climate trends persist.

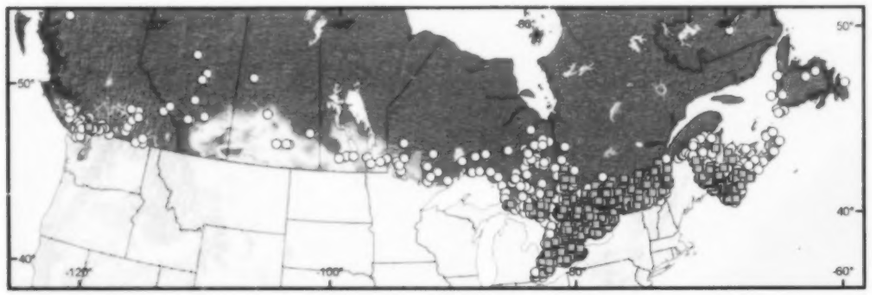
BioSIM is capable of determining spread probability for any species—insect, pathogen or plant—because it is designed to work with any model that encompasses an organism's life history and response to climate. This emphasizes the need to quickly acquire such information for any species that represents a significant risk to Canada's forests.

Sources

"Climate suitability and management of the gypsy moth invasion into Canada" will be published in the early 2008 issue of the scientific journal, *Biological Invasions*. "Impacts of climate change on range expansion by the mountain pine beetle" is available as Mountain Pine Beetle Initiative Working Paper 2006-14. Both papers are available through the Canadian Forest Service online bookstore.

Spatial distribution of gypsy moth recoveries from pheromone traps (yellow dots) and from sampling of other life stages (green squares) in Canada during the last 40 years (top map represents 1964 to 1970; bottom map represents 2001 to 2006). The darker the red in the background, the greater the probability of gypsy moth establishment due to suitable climate.





Warming ocean currents prevent Island outbreaks

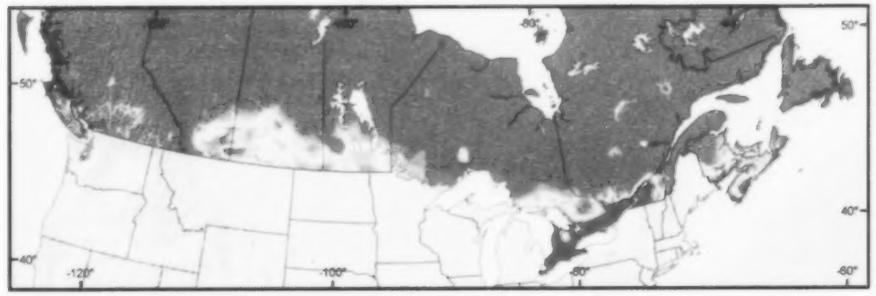
A century-long ocean-warming trend may explain the rarity of western spruce budworm outbreaks on southern Vancouver Island since the 1930s, according to a study by Canadian Forest Service Research Scientist Alan Thomson (athomson@nrcan-rncan.gc.ca) and Forest Climatology Research Officer Ross Benton (rbenton@nrcan-rncan.gc.ca). Mild winter temperatures, linked to a rise in sea temperature, have de-synchronized budworm–host interactions in the region: budworm larvae now emerge earlier in the year, while timing of bud flush of Douglas-fir, the defoliator's preferred host, remains unchanged. The trees do not respond to the early warming because their photoperiod requirements are already met by that time.

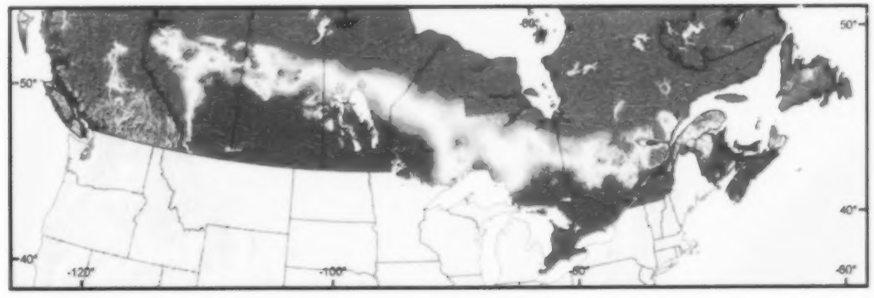
The good news does not extend beyond the south island, however: changing climate is believed to be contributing to a widespread 30-year budworm infestation in British Columbia's interior.

Source

"A 90-year sea warming trend explains forest defoliator outbreak patterns on Vancouver Island" will be appearing in *The Forestry Chronicle*, and will be available from the Canadian Forest Service online bookstore.

Potential distribution of gypsy moth in Canada based on probability of establishment due to climate suitability, projected from 2000 (top) seven decades into the future, to 2070 (bottom).





Software tool projects effects of changing climate o nge of forest pests

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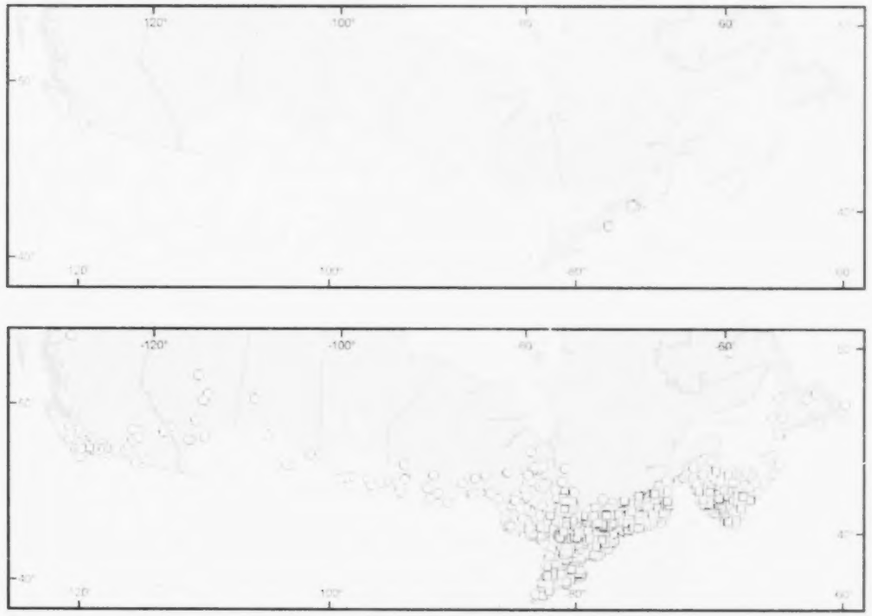

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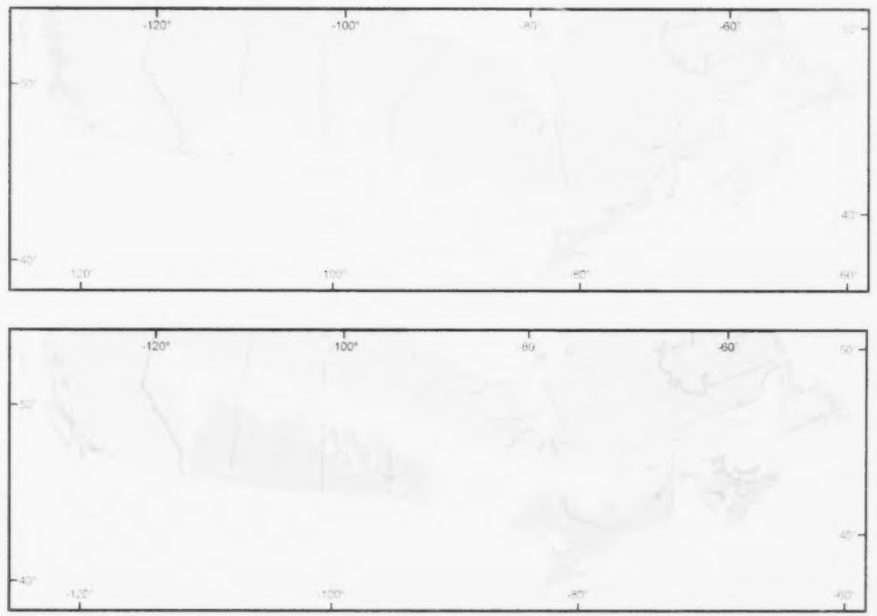


Community delivers moth-eliminating alternatives

Efforts to eradicate a gypsy moth infestation on British Columbia's Salt Spring Island demonstrate the power of community involvement and public spirit. When provincial forest health officials applied to the government for a permit to apply an aerial spray against the damaging non-native species in 2006, residents banded together and proposed alternatives, many of which residents themselves were responsible for implementing.

"We were very fortunate that one of our members is a forestry scientist and is aware of the issues and the British Columbia Ministry of Forests' concerns," says Leslie Wallace, spokesperson for Salt Springers Targetting Overuse of Pesticides, and leader of the island's gypsy moth control effort. "She put together a draft proposal, and as a group we fine-tuned it." When residents presented it to the British Columbia Gypsy Moth Technical Advisory Committee in early 2006, "they accepted everything, except for the section where we proposed to handpick caterpillars from trees."

"The tipping point," says Robb Bennett, a Ministry of Forests entomologist and member of the advisory committee, "was the community guaranteed sufficient people to do the alternatives, which included immense moth-trapping efforts and egg mass searches that required a huge number of volunteer hours. That was critical; it allowed the committee to say, 'Okay, we'll try your way.'"

In 2006, volunteers spent almost 600 hours hunting egg masses, assembled 2,700 moth traps, and hiked through bogs, brush and bramble patches to hang the traps. Several months later, they collected the traps and returned the data to the scientists. In 2007, they assembled, distributed and collected another 1,500 traps. The community group agreed with the province that use of a biological insecticide was a necessary evil, but convinced authorities to replace a planned aerial treatment of trees and bushes in infested areas with a ground-sprayed treatment using an insecticide formulation approved for use on organic farms. Had the formulation recommended by the province been used, local organic farms would have lost certification for three years.

For their efforts, Salt Springers Targetting Overuse of Pesticides received a 2007 community stewardship award from The Islands Trust.

Although it's too early to tell if the island is now gypsy moth free, resulting community awareness may serve to prevent other, future infestations.

"Gypsy moth infestations are preventable," says Natural Resources Canada Insect Ecologist Vince Nealis (vnealis@nrcan-rncan.gc.ca), also a member of the advisory committee. "The female moths are unable to fly, so the only way it can be introduced here is if somebody brings it in. The outbreak on Salt Spring Island happened because someone brought a car or something that had a gypsy moth egg mass attached from eastern Canada where the moth is established."

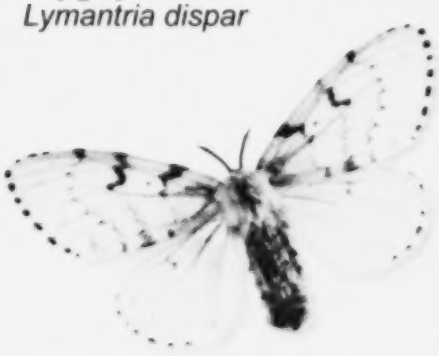
The Salt Spring Island moth control program seeks to build on current awareness of the issue to stop that from happening again. Publications, presentations, a website and display are planned, as are postcards asking new residents and others to request free inspection of their vehicles and outdoor items and report suspected egg masses, larvae or moths. A network of partners within the community will work to educate residents and visitors, and a number of residents will be trained to inspect vehicles and other items for egg masses.

"With the community spirit and level of commitment that exist on Salt Spring Island, this is a tremendous opportunity," says Nealis, "and it will go miles towards preventing future outbreaks on the island."

Alien pest profile

Gypsy moth: Asian strain & European strain

Lymantria dispar



At risk: Asian strain: 500+ (European: 300) species of broad-leaved trees and shrubs, and conifers (Asian only). Asian gypsy moth is an aggressive flyer and feeds on conifers. • **Native to:** Asia; Europe • **Distribution:** Asian strain: Asia; European strain: Asia, Africa, Europe, eastern North America. The European strain is widely distributed in eastern North America and is repeatedly introduced to western Canada by people moving from infested areas; eradication programs are underway. Asian strain occasionally introduced via ships arriving from infested ports in Asia. • **First Canadian record:** Asian - Vancouver, 1991 (eradicated); European - Quebec, 1924 • **Signs:** ragged, chewed leaf and needle margins; denuded shoots, twigs and branches

photo: Klaus Bolte, Canadian Forest Service

Cross-continent collaboration to control alien moth

Descendents of parasitic flies and wasps reared in Nova Scotia and released in Victoria, British Columbia, almost 30 years ago to control an exotic moth infestation are being shipped back across the continent to help suppress a similar infestation in the U.S.

From 1979 to 1983, researchers from the Pacific Forestry Centre and the British Columbia Museum of Agriculture released two species of parasites to control a local outbreak of winter moth, a European insect that was damaging broad-leafed trees and shrubs in the area's orchards, nurseries, and Garry oak forests. The parasites came from populations in Nova Scotia, where they had been used to control winter moth since the early 1960s, and from Europe.

Since those releases, Natural Resources Canada Integrated Forest Pest Management Research Scientist Imre Otvos and his team at the Pacific Forestry Centre have monitored moth densities and levels of parasitism at six sites throughout the Victoria region. They've found that host density dropped from about five moth larvae per leaf in 1980 to less than one moth per leaf in 1986, and that today the parasitic fly in particular continues to suppress local winter moth populations. Through the years, percentage of parasitism by the fly has ranged as high as almost 65 percent. Mortality caused by the other species, a parasitic wasp, is less important.

"The effectiveness of these parasite releases impressed our American colleagues," says Otvos (iotvos@nrcan-rncan.gc.ca). "Researchers from the University of Massachusetts contacted us in 2003, and we're now collaborating with them on a project to control the winter moth in Massachusetts and the northeastern U.S."

The parasites hatch and develop inside the moth pupae. In late summer, Otvos's team collects moth larvae from the monitored sites in Victoria, then ships about 10,000 of the cocoons to Massachusetts.

"The forests here are winter moth heaven: there are an estimated 100,000 larvae feeding on each tree," says University of Massachusetts (Amherst) Entomology Professor Joe Elkinton, who visited the Pacific Forestry Centre in 2005 to learn Otvos's larvae-rearing techniques.

Elkinton's lab receives the winter moth cocoons and rears them. If winter moth adults emerge, they are destroyed. Parasitized cocoons yield only parasitic flies and the occasional parasitic wasp. These emerge in spring, mate, and are released into infested forests just before they start laying eggs.

Alien pest profile

Winter moth

Operophtera brumata

At risk: oaks (including Garry oak) maples, basswood, ash, fruit trees and shrubs, and some spruces including Sitka spruce in Scotland • **Native to:** Europe • **Distribution:** Europe, northeastern and northwestern US, Canadian Maritimes, south-coastal B.C. • **First Canadian record:** 1949 in Nova Scotia • **Signs:** holes in leaves and ragged edges. If larvae destroy the entire leaf crop, they often drop from the tree in search of food. Trees completely stripped of their foliage may produce new leaves in mid-summer. These new leaves are usually light green.

photo: Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org

"We've been releasing several hundred of the flies each year," says Elkinton, "and last year we were able to release about 1200 flies." After four years, the researchers have started recovering the flies from the forests.

"That tells us the fly is beginning to get established," he says, "and that its populations may grow enough to start reducing the winter moth populations here."

Funding from the university and the State of Massachusetts covers costs incurred by Otvos and his lab in the collaboration.

Biocontrol pesticide safety examined

The insecticide known as Btk is the most widely used insecticide in forestry in Canada. Based on the common soil bacterium, *Bacillus thuringiensis* subspecies *kurstaki* (Btk), it is used in a spray to control spruce budworm and the non-native gypsy moth.

Natural Resources Canada Research Scientist Imre Otvos (iotvos@nrcan-rncan.gc.ca) and his team at the Pacific Forestry Centre recently reviewed all available studies and reported cases of effects of Btk on humans and large mammals. The studies document that people with severe allergies or suppressed immune systems may be slightly affected if exposed to Btk, but most people can eat, breathe and drink Btk in quantities they would likely be exposed to during aerial-spray pesticide application without adverse effect.

Based on the accumulated information, "Btk may be the safest bio-pesticide currently available," Otvos says. It requires an alkaline gut, as caterpillars of some moth species have, to be toxic; mammals have acidic guts and destroy injested bacteria during digestion. Sunlight also destroys Btk, limiting its longevity as an effective pesticide once it is applied.

Source

"Safety of *Bacillus thuringiensis* var. *kurstaki* Applications for Insect Control to Humans and Large Animals" can be downloaded from the Canadian Forest Service online bookstore. It is part of the *Proceedings of the sixth Pacific Rim Conference on the Biotechnology of* Bacillus thuringiensis *and its Environmental Impact, Victoria, British Columbia, 2005*, published by Agriculture and Agri-Foods Canada.

BioControl 101: Critter complex under investigation

A murderer that targets the sick and injured and kills them with poisonous injections... A creature that preys on the young, then occupies their reproductive systems so that when victims mature, mate and give birth, they give birth only to more and more of the parasitizing monsters.

Biological control could provide inspiration for any number of horror films, but the B-movie-type roles described here are subjects of an investigation by a team of federal and provincial scientists to determine whether an alien insect that threatens Canada's pine forests could be controlled by natural enemies.

It's all part of BioControl 101, says Great Lakes Forestry Centre Plant–Insect Interactions Research Scientist Peter deGroot. "You need to understand what's in the system already before you even consider managing it or introducing a biocontrol agent."

In this case, the role of murderer is played by *Sirex noctilio*, a woodwasp native to Europe, Asia and northern Africa that has devastated pine forests in South America, New Zealand, Australia and South Africa, and has recently been found attacking Scots, red and jack pine in more than 40 locations across much of southern and central Ontario. *Amylostereum areolatum*, a fungus that weakens tree defences, is Sirex's sidekick. And the creepy creature that takes over its prey to reproduce is the hero. Forest managers use nematode *Beddingia siricidicola* to control *S. noctilio* populations and damage in many Southern Hemisphere countries experiencing severe infestations.

Canadian Forest Service Research Biologist Isabel Leal (ileal@nrcan-rncan.gc.ca), at the Pacific Forestry Centre, is trying to determine if *B. siricidicola* would maintain its hero status in Canadian forests. She is developing DNA tests for identifying *B. siricidicola*, which parasitizes *S. noctilio*, and other closely related nematode species that do not, including native species. "What species do we already have? How similar are native species to the biocontrol species? How do they interact with the environment here and with each other?"

DeGroot (pdegroot@nrcan-rncan.gc.ca) is examining the insect's biology and ecology. He is also looking at other insects that may be competing for the stressed pine wood-feeding niche preferred by the woodwasp or may be predisposing potential host trees to woodwasp attack. Other native natural enemies that may be influencing *S. noctilio* populations also interest him.

At Laurentian Forestry Centre, Forest Pest Biotechnology Research Scientist Richard Hamelin (rhamelin@nrcan-rncan.gc.ca) is investigating the fungus side of the *S. noctilio* complex: different strains *Amylostereum areolatum* found in association with the woodwasp in Canada, the influence those strains have on insect and nematode, and competing fungus species.

The work, which also involves researchers from Agriculture and Agri-Foods Canada, the Canadian Food Inspection Agency and the Ontario Ministry of Natural Resources, is still preliminary; fortunately *S. noctilio* populations remain at low levels. But, Leal says, it's best to try now to answer the basic questions about biocontrol feasibility, especially as *B. siricidicola* is not a universally successful *S. noctilio* biocontrol agent: it failed to establish in South Africa despite repeated releases, and may also fail in Canada.

"We've learned from the South African experience to not think of this nematode as a magic bullet to prevent or reduce major infestations, because it may not work here either."

Alien pest profile

Sirex woodwasp

Sirex noctilio

At risk: pine, spruce, fir, larch and Douglas-fir • **Native to:** Eurasia • **Distribution:** Asia, Australia, New Zealand, South America; Africa; Europe; New York state and Pennsylvania; southern Ontario (eradication and monitoring underway; biocontrol options are being investigated) • **First Canadian record:** Ontario and Quebec, 2004; it was probably introduced several years before that. • **Signs:** Wilting and discolouration of needles; tunnels packed with sawdust; circular emergence holes.

photo: David R. Lance, USDA APHIS PPQ, Bugwood.org

People

Accolades

Rich Hunt has received the Western International Forest Disease Work Conference Distinguished Achievement Award for his work on the white pine blister rust–western white pine pathosystem. Hunt, who retired from the Canadian Forest Service in 2005, was leader of Natural Resources Canada's White Pine Blister Rust Project to determine genetic resistance to blister rust in western white pine. Because of Hunt's work on this disease, white pine is now a manageable timber species in British Columbia.

Advances

Phyllis Dale brings her experience in molecular biology to bear in her new role as the Pacific Forestry Centre's Herbarium and Molecular Biology Research Technician. Prior to joining the Canadian Forest Service in 2004, she worked in the Department of Microbiology and the Department of Biological Sciences, at the University of Alberta, where she was involved in various molecular- and phylogenetics research projects and taught undergraduate courses. She completed her Ph D. in Plant Science (Plant Molecular Biology) at the University of Alberta in 1996.

Geospatial Scientist **Brian Low** was recently appointed Manager of the National Forest Information System. He has been involved in the web-based, open-source information-sharing system's development since its conceptual and planning stages nine years ago. Prior to joining the Canadian Forest Service in 1998, Brian worked for the British Columbia Ministry of Environment, Lands and Parks as a geographical information system specialist: his work included using terrestrial and climatic data to model rare and endangered animals and developing provincial digital standards for terrestrial ecosystem mapping.

Gurp Thandi has taken on the role of Geographic Information Systems Technologist with the Pacific Forestry Centre Fire Research group. Thandi has worked with a number of different research groups at the centre during the last six years, and brings his varied experience in GIS applications and data analysis to his new position.

Departures

After more than 30 years providing forest-insect diagnostic services for the Canadian Forest Service and its collaborating agencies in British Columbia and the Yukon Territory, Insectary Biologist **Bob Duncan** retired from the forest service this fall. The Canadian Forest Service published a compilation of Duncan's extensive knowledge of caterpillars and sawfly larvae in 2006 in the publication, *Conifer Defoliators of British Columbia*. Duncan leaves the Canadian Forest Service to pursue his interest in fruit gardening: his small orchard on southern Vancouver Island include more than 370 varieties of temperate and subtropical fruits.

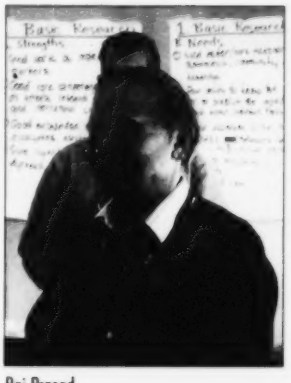
Retired Research Scientist Rich Hunt (right) with Forest Biology Director Gary Hogan

Another long-time researcher retired this fall: Plant Physiology and Weed Science Research Scientist **Raj Prasad**. At the Pacific Forestry Centre, Prasad concentrated on investigating the invasiveness, impacts and control of exotic weeds in forestry. Before that, he worked at Sault Ste Marie's Forest Pest Management Institute, researching herbicides for forest management, and at the Chemical Control Research Institute of the Canadian Forest Service in Ottawa, investigating control of vascular wilts and spruce budworm.

Brian Low

Land-Use Change Specialist **Dennis Paradine** left the Pacific Forestry Centre this fall for a position with the British Columbia government. Paradine joined the Canadian Forest Service in 2002 to develop methods for mapping permanent land-use change of forestlands for use in the Canadian Forest Service Carbon Budget Model. He designed and conducted analyses of remote sensing, inventory and other records with federal, provincial and private collaborators to estimate rates of deforestation in Canada, and was a member of Canadian Forest Services' Digital Remote Sensing Team and Carbon Accounting Team.

Laura Byrne, Natural Resources Specialist with the Canadian Forest Service, recently moved on to become GIS Analyst with the District of Sooke, Vancouver Island. While at Pacific Forestry Centre, she helped federal departments such as the Department of National Defence and the National Research Council of Canada to manage their forestlands on southern Vancouver Island. Her work included management and implementation of Interdepartmental Recovery Fund (Environment Canada) projects to protect species at risk, management of natural areas, and assistance with environmental assessments.



Raj Prasad

New from the bookstore

The State of Canada's Forests: Annual Report 2007.

L'État des forêts au Canada: Rapport annuel 2007.

Forest insect pests in Canada. Mountain pine beetle. (Poster) (Insectes nuisibles des forêts au Canada. Dendroctone du pin ponderosa. (Affiche)).

Forest insect pests in Canada. Gypsy moth. (Poster) (Insectes nuisibles des forêts au Canada. Spongieuse. (Affiche)).

National Forest Week, September 23–29, 2007. Canada's natural resources: tradition and transition (Poster) (Semaine nationale de l'arbre et des forêts, du 23 au 29 septembre 2007. Les ressources naturelles du Canada : tradition et transition (Affiche)).

Model-based, volume-to-biomass conversion for forested and vegetated land in Canada. 2007. Boudewyn, P.A.; Song, X.; Magnussen, S.; Gillis, M.D. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Information Report BC-X-411.

The Mountain Pine Beetle Program. 2007.

A silvicultural assessment of 10 lodgepole pine stands after partial cutting to reduce susceptibility to mountain pine beetle. 2007. Whitehead, R.J.; Russo, G.; Hawkes, B.C.; Armitage, O.B. Natural Resources Canada, Canadian Wood Fibre Centre, Victoria, B.C.

Events

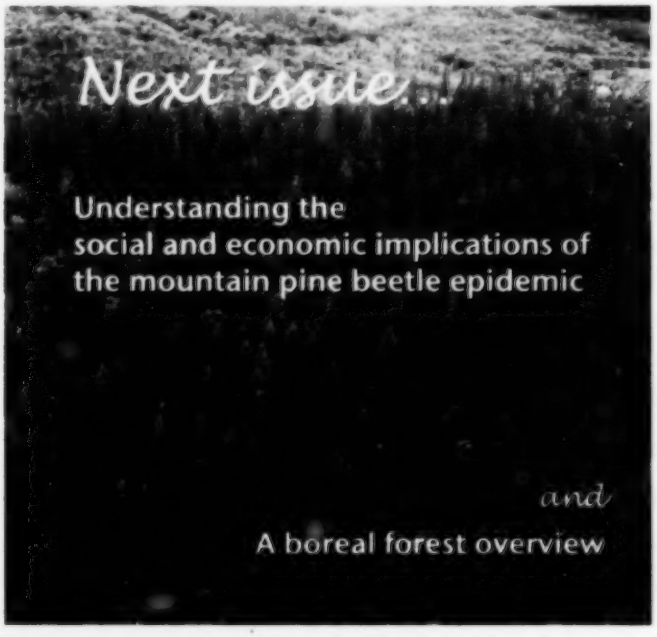
ForestEdWest 2008:
A conference dedicated to forest education in western Canada
January 24–27, 2008
Kelowna, B.C.
Information: www.forestedwest.ca

ExpoFor 2008
February 20–22, 2008
Penticton, B.C.
Information: www.abcfp.ca

Council of Forest Industries (COFI) AGM
April 16–18, 2008
Kelowna, B.C.
Information: www.cofi.org

The Road to the Future Forest:
Canadian Institute of Forestry 100th AGM and 2008 Conference
September 7–10, 2008
Fredericton
Information: http://www.cif-ifc.org/english/e-agms.shtml

Entomological Society of Canada
58th Annual Meeting
Joint Meeting with the Entomological Society of Ontario
October 18–22, 2008
Ottawa, Ontario
Information: esc-sec.org/agm.htm



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